**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, D.C. 20554**

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| In the Matter of | ) | |
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| | ) | |
| Information Sought on Methods | ) | |
| for Verifying Compliance with | ) | ET Docket No. 99-300 |
| E911 Accuracy Standards | ) | |
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To: The Commission October 29, 1999

## COMMENTS OF TECHNOCOM CORPORATION

TechnoCom Corporation hereby respectfully submits the following comments in response to the Commission's Public Notice, DA 99-2130, requesting information on methods for verifying compliance with Enhanced 911 (E911) accuracy standards. The Public Notice indicates that the Office of Engineering and Technology (OET) and the Wireless Telecommunications Bureau (WTB) are seeking technical information on measuring the accuracy of E911 systems for locating wireless callers. Therefore, TechnoCom herewith offers its views on methods for testing and measuring location determination accuracy based on its experience in designing, deploying and testing location systems for wireless E911, Location and Monitoring Services (LMS), and GPS-based Automatic Vehicle Location (AVL).

TechnoCom Corporation is a wireless systems engineering and product development company with offices in Encino and Encinitas, California (www.technocom-wireless.com). TechnoCom has extensive experience in E911 and LMS location system design, analysis, development, deployment and testing. TechnoCom has assisted a variety of E911 technology developers and wireless carriers including deployment of two trial systems in California, analysis and reporting of test results for a field trial in Texas, and investigation of location system design considerations caused by the various digital wireless standards. TechnoCom's other relevant experience includes design, deployment and testing of LMS networks in 20 cities across the country and implementation of GPS-based AVL systems using different wireless networks for a variety of customers.

TechnoCom's two-tiered E911 location accuracy proposal (i.e., 67 percentile and 95 percentile accuracy specifications)[1] was adopted by the Commission and has been incorporated into its latest ruling on E911 location requirements.[2] Finally, through its experience in analyzing, designing and deploying various wireless location systems, TechnoCom has developed location system analysis tools (software and test equipment) and procedures to predict and analyze the coverage and performance of location systems, including E911 and LMS systems. TechnoCom was invited to present an overview of

[1] Comments of TechnoCom Corporation filed June 17, 1999 in response to the Commission's request for targeted comment on wireless E9-1-1 Phase II Automatic Location Identification requirements (DA 99-1049) in CC Docket No. 94-102.

[2] FCC 99-245, released October 6, 1999, Third Report and Order in CC Docket No. 94-102, at paragraph 76.

location system implementation and verification considerations at the NENA Technical Development Conference (TDC) in March of 1999.[3]

Based on its relevant experience and expertise, and its vendor/technology neutral position, TechnoCom wishes to express to the Commission its views on appropriate methodologies for verifying compliance with wireless E911 accuracy standards and other technical requirements. In these comments, TechnoCom has tried to address the most salient questions posed in DA 99-2130. These suggestions are intended to serve as guidelines for developing specific location system evaluation procedures and methods. TechnoCom looks forward to assisting OET and WTB to the extent possible as they execute their assigned task of developing and publishing methods that may be used for verifying compliance with the Commission's Rules.[4]

Statistical Considerations

*1) Number of Measurements*

Wireless systems, including location systems, can typically be tested for coverage and performance by dividing the system into geographical bins. For this application, TechnoCom proposes that 1 km × 1 km bins within the coverage area of the wireless network be used as the unit of measure. A sampling of bins may be randomly, or otherwise, selected from the entire coverage area. The number of bins selected for testing

[3] The presentation made at the March 1999 NENA TDC panel session is available on TechnoCom's web site at http://www.technocom-wireless.com/E911/LocPerf. For a hardcopy of this presentation, please contact the author, Mario Proietti, at mproietti@technocom-wireless.com or 714-577-8075.

[4] DA 99-2130, page 2, paragraph 1.

should be adequate to represent the variety of geographic, terrain, foliage and land-use characteristics of the overall coverage area.

For statistical confidence each bin should contain at least 100 test locations (i.e. 100 test calls placed within each bin). Within each bin, the test locations should be selected to include stationary, mobile and indoor (and possibly other) scenarios in appropriate proportions consistent with the general characteristics of the particular bin. Test locations should be appropriately identified (labeled) in test data logs so that future analysis may take into account the conditions under which the data was gathered (i.e., indoor, outdoor, mobile, stationary, etc.). It may be advisable that a fixed and well documented set of "scenarios" or test cases be defined to facilitate uniform assessment over time and in comparing the performance of one system versus another.

With this method, the location system's performance is averaged within each geographical bin, and the overall system performance is determined by weighting the "importance" of each bin and averaging over the total number of bins (the weighting of bins is discussed in greater detail below). This weighting prevents data from being skewed when there are excessive numbers of measurements within certain geographical areas and very few in others. This method also allows test data to be reprocessed as the "importance" of bins changes over time without the need for gathering new test data.

This method allows the location system performance to be measured in a variety of areas with sufficient statistical confidence even for those areas in which only a few E911 calls might be placed. Collection of sufficient data and weighting by population and/or call density would adjust the "importance" of particular bins when applied to assessing the system's performance for the overall coverage area.

It is difficult to further characterize testing guidelines without differentiating between systems that cover, for instance, large metropolises versus rural areas. Choosing the number of bins to validate compliance is a complex issue that depends on the size of the system coverage area, the population and diversity of bin characteristics. For example, in large metropolitan areas these bins should be chosen at random with a balanced mixture of dense urban, urban, suburban and rural environments. In addition, some systems may cover several metropolitan areas, for example the Southern California region, in which case other criteria may be considered such as jurisdictional or political boundaries.

For areas with lower population density or in rural areas the bins should also be chosen at random; however, the number of bins might be fewer.

In any case, other considerations should be taken into account in selecting the actual bins to be used such as the availability of wireless service and accessibility by roadways. The overall goal should be to utilize enough bins to assure statistical confidence. The number of bins required to test each individual system, whether large or small, could be determined through the design of a test procedure that can be verified and approved by an independent evaluator.

Assuming the number of bins has been chosen, this methodology would allow compliance verification through a reasonable amount of work. For instance, if 100 bins with 100 test locations per bin are used to test compliance for a certain system, a test team could accomplish the data gathering within 10 days at a rate of 1,000 calls per day.

*2) Precise Statistical Model*

A particular method of analysis should be specified in the test procedures that would include how the results are to be statistically evaluated consistent with the accuracy standards imposed by the Commission. Comments that follow suggest a particular method for analyzing the test data.

*3) Special Considerations for "Outliers" and Large Location Errors*

TechnoCom believes that the Commission's accuracy standard of 300 meters for 95% of calls alleviates the need for treating "outliers" as a special case. In a location system that is operating reliably, the outliers should fit well within the 5% of points that are excluded from the location accuracy standard. If desired, these points may be scrutinized to determine if at least a Phase I solution (cell/sector and ANI) was obtained for the affected calls. While not a test of the location system itself, this could be used to validate that at least Phase I capabilities are available in those cases when Phase II location attempts are not successful (e.g., due to environmental conditions, malfunctions, etc.). Since the Commission did not set a standard for the treatment of "outliers", the assessment of these results would appear to be useful for information purposes only.

*4) Precision of Actual Caller Location and Location Measurements*

Differential GPS (DGPS) provides a sufficiently accurate reference for the caller's actual location in order to determine compliance with the Commission's rules. However, if the testing is to be used for more detailed comparison or evaluation, then a higher degree of accuracy may be desired. However, to assess E911 compliance, DGPS

accuracy and 1 meter resolution in logging of test data and reporting of results should be more than adequate. If higher precision is desired, substantially more sophisticated test equipment and time consuming procedures may become necessary.

Locations can be matched to the DGPS data by using a time stamp filter which assures that in mobile cases the latency and/or time offsets between the DGPS location fixes and the location system fixes do not significantly affect the test results. In stationary test cases, the need for time synchronization is less critical. The DGPS location should be updated often enough so that it can be easily correlated with the E911 data. Additionally, specialized software and/or hardware may be used so that a DGPS reading is recorded at the start of every E911 call and/or request for an updated location fix[5].

TechnoCom believes that it is sufficient to measure the reference locations with an accuracy of 3 to 5 meters, the estimated accuracy of conventional DGPS equipment, thus not requiring elaborate instrumentation. A measurement resolution of 1 meter for fixes from both the location system under test and reference location system (e.g. DGPS), should be sufficient for assessing compliance with the Commission's rules.

For indoor test cases, an alternative method to DGPS may be necessary to obtain the precise location of the caller (to within 3 to 5 meters). Use of building surveys, engineering drawings and standard measuring and surveying techniques may be the most economical way to accomplish this.

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[5] TechnoCom has developed location system test equipment and processing software that provide a mechanism for synchronizing the determination, logging and comparison of location fixes from the DGPS reference and the location system under test.

Choice of Measurement Locations

*1) Coverage Area*

TechnoCom proposes that the randomly selected bins suggested previously should be selected from the entire advertised coverage area of the wireless carrier's system (including boundary regions). Inability for a call to be completed should not be counted as a failure of the location system. However, such occurrences should probably be noted and reported to the wireless carrier.

Given the proposed method of randomly selecting geographic test bins and weighting the bins according to importance, a variety of weighting rules may be applied to assess location performance. Such weighting might be based on jurisdictional or political boundaries. Such weighting could, however, be done after the test data is gathered and does not necessarily need to affect the testing and data gathering itself. This approach would allow the results from a single test campaign to serve as the input into a variety of assessment goals (e.g., by jurisdictional boundaries, land-use characteristics, indoor/outdoor, stationary/mobile, etc.).

*2) Choice of Test Locations*

TechnoCom recommends that test locations be chosen randomly. The geographic bins and the test locations within each bin should be chosen at random, keeping in mind that the goal is to have at least 100 points in each geographical bin. Also, the selected test points within each bin should include a variety of test cases (e.g., indoor, outdoor, mobile, stationary, etc.) reflective of the characteristics of the respective bin. Each

carrier and/or PSAP may make up its own test cases within such established guidelines to be verified by an independent evaluator.

Test locations not made outdoors or at street level may require the use of an alternative reference location method other than DGPS such as conventional geographic surveying. Any surveyed test points should be documented so that they may be used for subsequent testing over time.

Since the Commission's rules do not currently require determination of vertical position within a specified accuracy, the collection of vertical position information would seem to be optional. Selecting test points within upper floors of multiple story buildings would be advisable to achieve a full test of the location system, however the vertical component of measured locations should be logged for informational purposes only.

In those areas where foliage and/or building changes occur, testing should be repeated at sufficient intervals (and at appropriate times) to accurately assess the effects of the changing condition. The use of well-documented test points would allow comparison of test results gathered at different times to be compared with greater confidence by allowing the ability to repeat testing at the same test points. However, if the test data sample size is sufficiently large (as suggested), the use of exactly the same test points should not be necessary.

Another issue that should be considered in assessing location system performance is on-going monitoring of system compliance. Over time, the performance of a location system may vary due to changes such as those mentioned in the questions as well as due to changes in the system deployment, equipment degradation, etc. Unless on-going monitoring or periodic testing is conducted, the actual performance of the location system

may not be known. In wireless communication networks, whose performance is obvious by its normal use, users will detect (and complain about) poor voice quality or coverage holes. However, the performance of a location system may be less obvious unless it is compared against a reference for each location (or sample set of locations). Therefore, it is recommended that methods for on-going verification be addressed as part of the OET and WTB efforts to develop test procedures.

Measurement Techniques

*1) Time Limits on the Location Fix*

Time limits on the location fix may be imposed by the Commission to meet the operational requirements of the PSAPs. Also, if the reported location is being used to route the call to the correct PSAP, the location must be determined during the call setup process which would impose additional time constraints depending on the routing equipment and mechanism in use. Otherwise, 5 to 10 seconds would appear to be a reasonable range. However, this is more of an operational constraint than a technical one and therefore may be more appropriately addressed by the PSAP community and routing equipment vendors.

*2) Phone Selection*

It is sufficient to use only portable phones for the test. The vast majority of users today rely on portable phones, both outside and inside vehicles. Mobile phones can typically transmit at equal or higher power levels and should perform at least as well as the portables for all location technologies.

*3) Test Cases*

Location performance should take into account both stationary and non-stationary users (including walking and driving) as well as both indoor and outdoor use. Depending on the location technology under test, performance may vary dramatically from case to case. Therefore, a balanced number of calls representing each test case should be used. This mixture could be based on 911 call statistics or other known demographic or usage patterns. In all cases, the collected data should be annotated to indicate the type of test case represented by the recorded location test samples. This would allow future processing and analysis of the results for specific test cases while using a single test data collection campaign.

*4) Differentiation Between Analog and Digital Phone Service*

The analog and digital coverage area of cellular systems may differ significantly. In addition, separate location systems may be required for each technology and even if a common system is used, its performance may vary significantly depending on the air interface in use by the phone. Hence, TechnoCom proposes that separate test data be collected for each air interface addressed by the location system under test. This may also be true for certain handset and GPS-based systems that may rely on the data communications characteristics of the wireless networks and therefore may be influenced by differences therein.

Analysis and Presentation of Test Data

*1) Analysis*

TechnoCom proposes that the test data be weighted according to the population characteristics, subscriber density or E911 call volume of each geographical bin. A simple method for weighting these bins would be to consider the population density of each postal zip code either wholly or partly covered by the system. Each bin's weight can be determined by considering the percentage of the total population contained in its zip code compared to all the zip codes within the coverage area. Each bin could be weighted according to the zip code into which it falls, and in the case of bins overlapping more than one zip code, each bin could be weighted by a majority rule. Other data may also be used to establish bin weighting if available such as E911 call volumes, overall call volumes, subscriber densities, etc. In any case, analysis of the test data could be done through the use of application-specific post processing software.

*2) Presentation of Results*

The results may be presented graphically (geographically or otherwise), as well as in chart (pie, bar, line graph, histogram) or tabular form. Also, test data that is gathered using the suggested methods may be applied to refine and/or validate the results of location system coverage and performance predictions used in the design and deployment of the location networks. Such predictions are normally presented as thematic (color coded) maps representing performance of the system over the geographic coverage area.[6]

[6] See http://www.technocom-wireless.com/E911/LocPerf for examples of location system performance presentation formats.

TechnoCom believes that these comments and suggestions will help create accurate and fair test procedures that verify compliance with the E911 location standards established by the Commission.

Respectfully submitted,

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